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Wind-Speed and Wind-Direction Distributions at Argus Island off Bermuda

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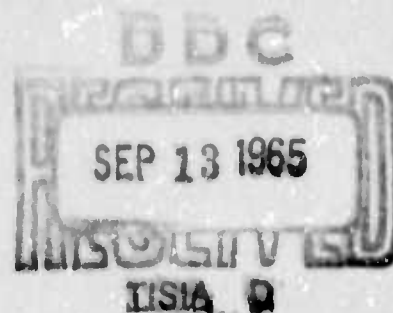
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ABSTRACT

Argus Island wind information was systematically recorded and processed over a three-year period. The recording, processing, and analysis procedures used are described. Monthly mean wind speeds with standard deviations are compared with monthly median wind speeds and quartiles. Monthly distributions of wind speed are given, as well as yearly distributions. Cumulative distribution plots compare wind-speed occurrences over the three-year period. A time plot of daily mean and maximum wind speeds is given, and diurnal variations are discussed. The distributions of wind direction for each month are also shown.

ADMINISTRATIVE INFORMATION

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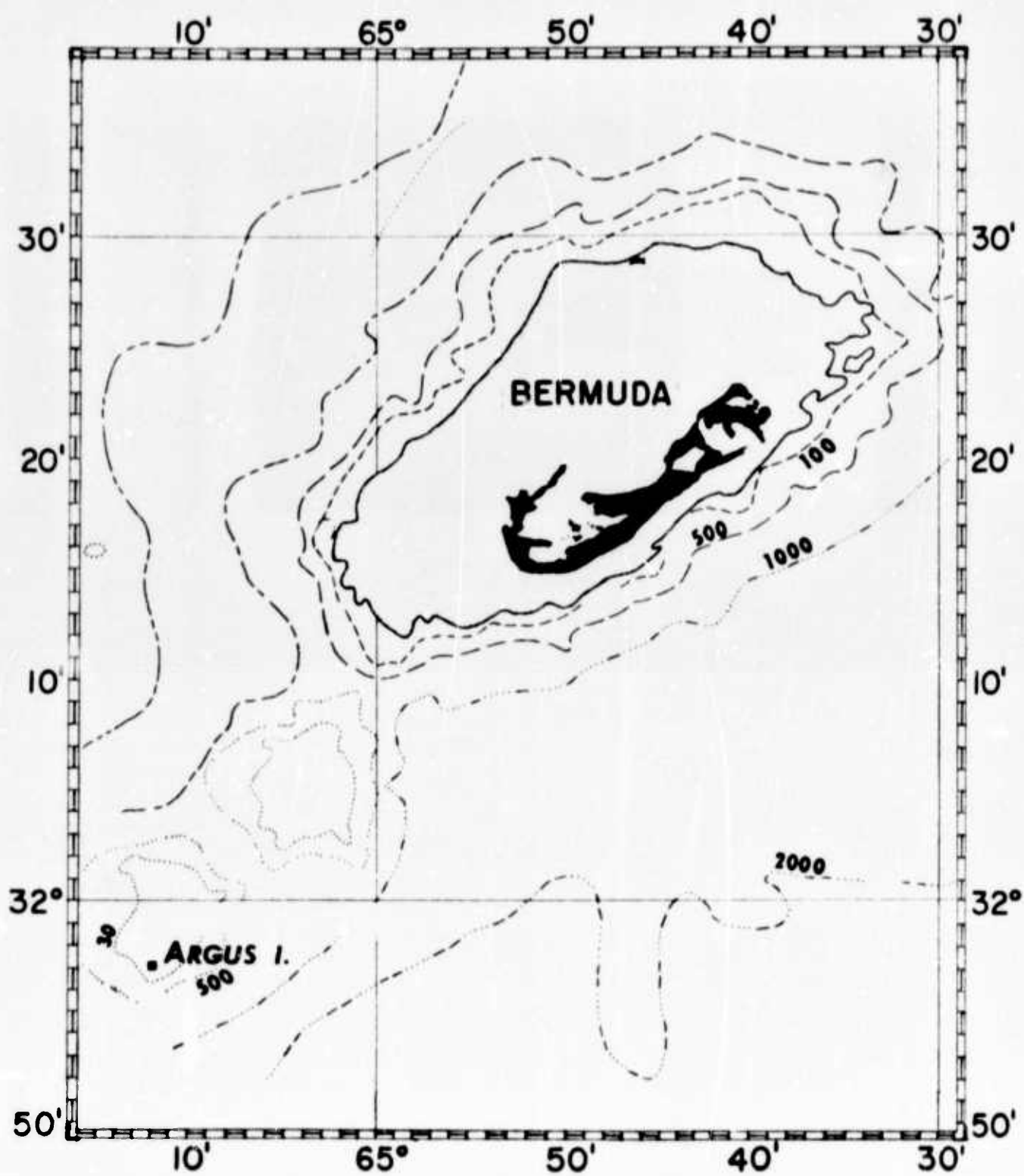


Fig. 1 - Location of Argus Island

WIND-SPEED AND WIND-DIRECTION DISTRIBUTIONS AT ARGUS ISLAND OFF BERMUDA

INTRODUCTION

The data reported here were gathered in connection with an ARTEMIS measurement program carried out by resident personnel at the USL Bermuda Detachment. The data were recorded at Argus Island, a tower located on a sea mount in 190 feet of water. (See Fig. 1.) Argus Island stands in the open sea approximately 28 miles from Tudor Hill Laboratory, which is on the southwest coast of Bermuda.

Systematic recording and processing of wind information over a three-year period produced a volume of data that may serve other purposes. Preliminary information has been previously published;¹ in this report the data are consolidated and related. The recording, processing, and analysis procedures used are described. Monthly mean wind speeds with standard deviations are compared with monthly median wind speeds and quartiles. Monthly distributions of wind speed are given, as well as yearly distributions. Cumulative distribution plots compare differences in wind-speed occurrences over the three-year period. A time plot of daily mean and maximum wind speeds is given and diurnal variations are discussed. The distributions of wind direction for each month are also shown.

¹ F. G. Weigle, "Sea Condition Information from Argus Island, Monthly Plots from December 1960 to June 1962," Informal USL Memorandum, Laboratory Research Detachment, Bermuda, 12 July 1962; F. G. Weigle, "One Year's Wind and Sea Observations at Argus Island," USL Memorandum 906.1-4, 20 July 1962; and F. G. Weigle, "Argus Island Wind and Wave Data, 1 August - 30 November 1962," USL Memorandum 906.1-1, 1 January 1963.

DATA RECORDING AND PROCESSING

All data were obtained from an AN/UMQ-5A recording anemometer system installed by the Navy Oceanographic Office on Argus Island. Data were recorded by an Esterline-Angus inked oscillographic trace at a chart speed of 1/20-inch per minute. Figure 2 shows the wind-speed and wind-direction sensors mounted on the top of the microwave tower at the right-hand edge of the structure.

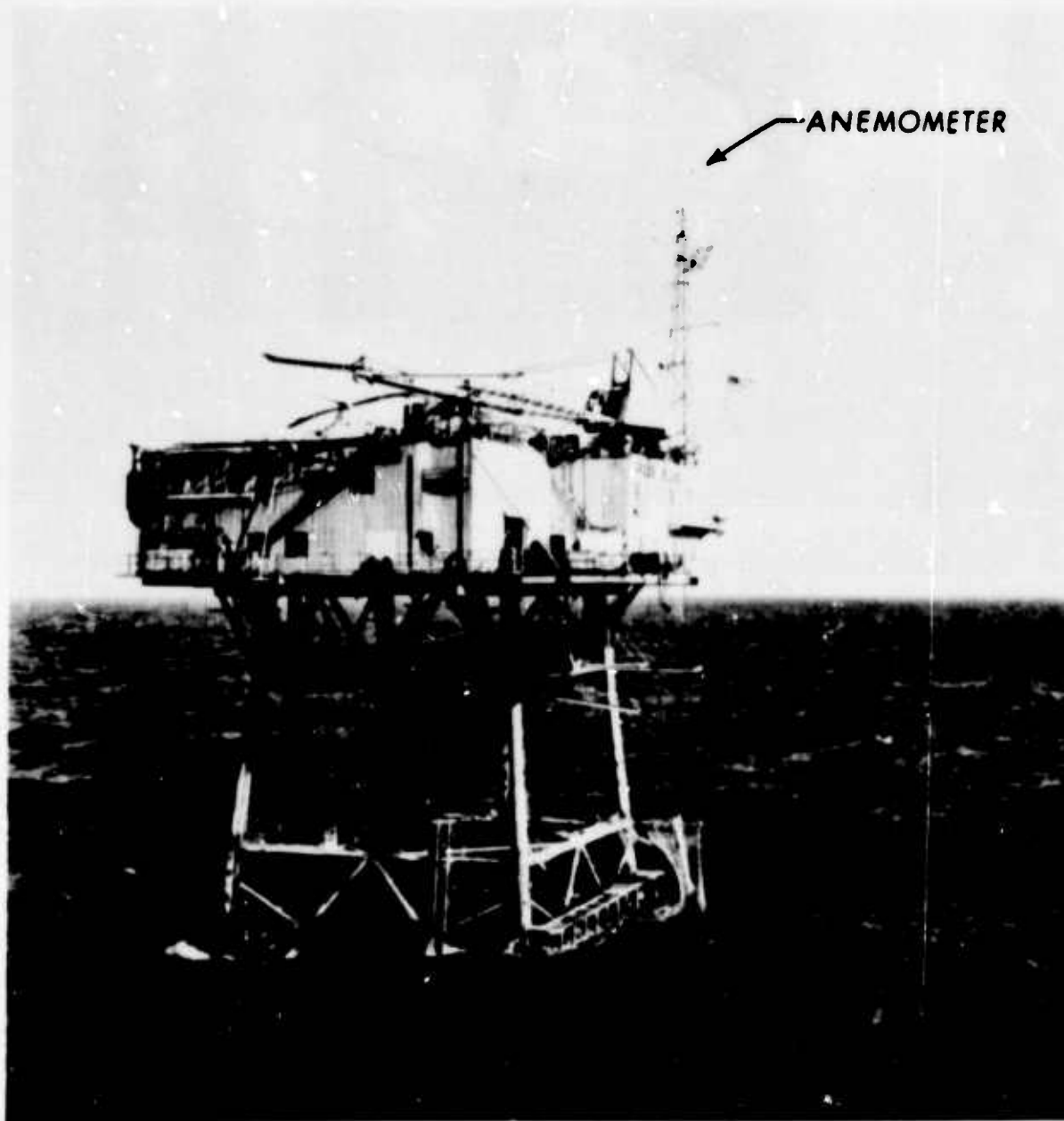


Fig. 2 - Argus Island

Data reading was initially performed by eye-averaging each 10-minute interval on the recorded trace, which at a chart speed of 1/20-inch per minute, is 1/2-inch long. An eye average here presents no problem and is "good" to ± 0.5 knot.

Since the above procedure resulted in a volume of data points excessive for our purposes, it was discontinued except for specific periods of intense observation. Readings of average values on the hour were substituted and continually plotted against time on a weekly basis. A sample of such a plot is shown in Fig. 3. The hourly readings are the basis for this report.

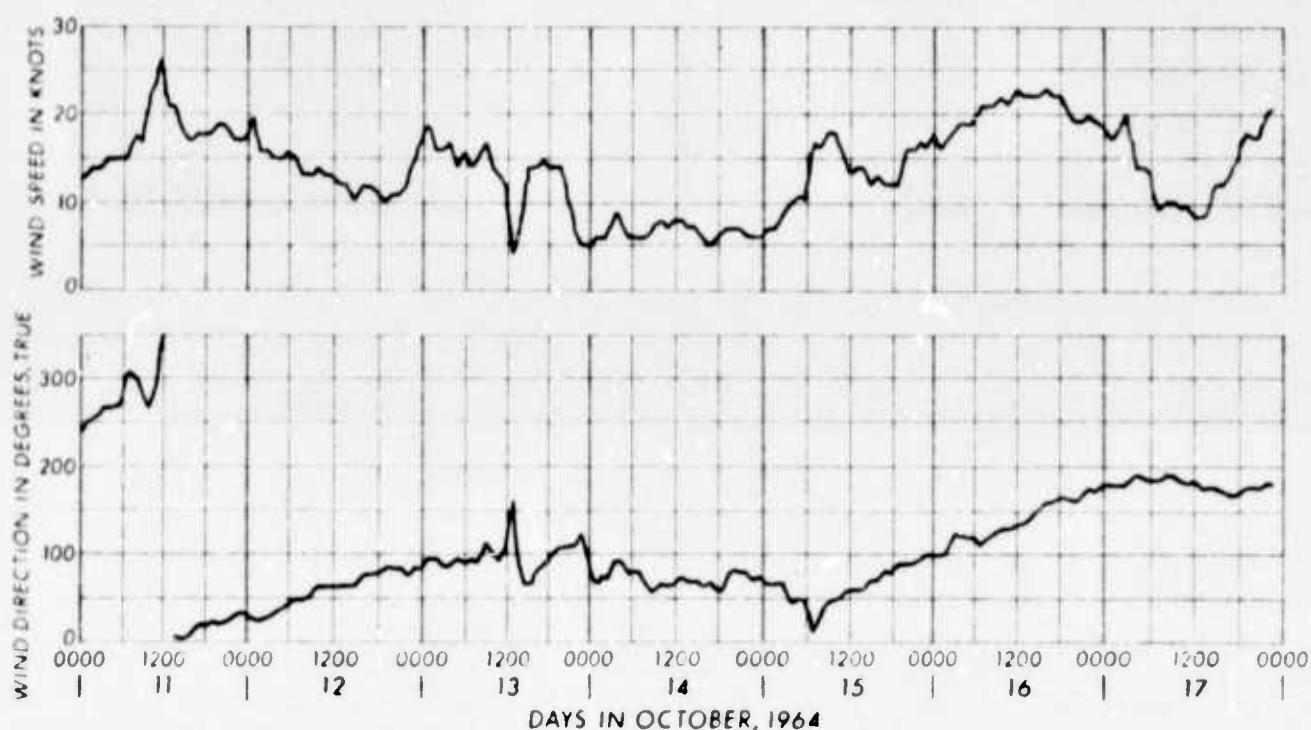


Fig. 3 - Sample of Wind-Data Plot

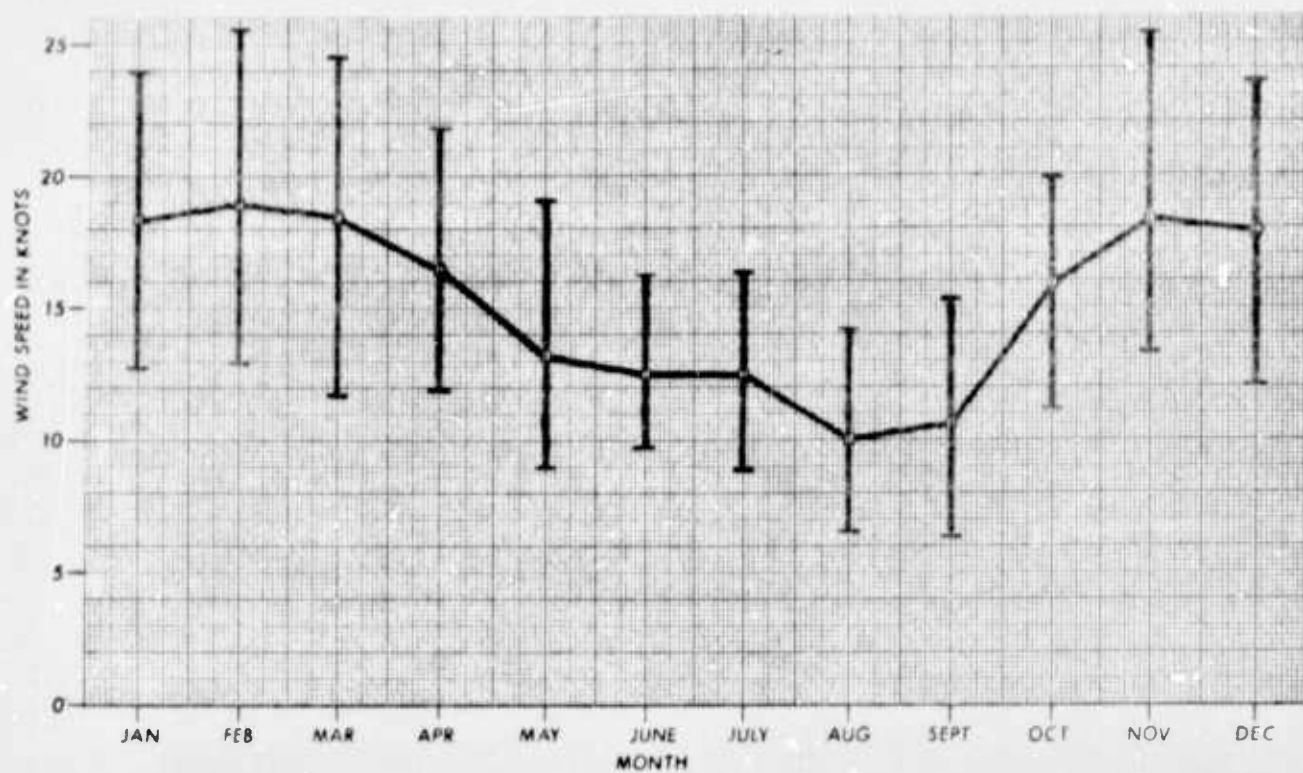


Fig. 4 - Monthly Median Wind Speeds and Quartiles

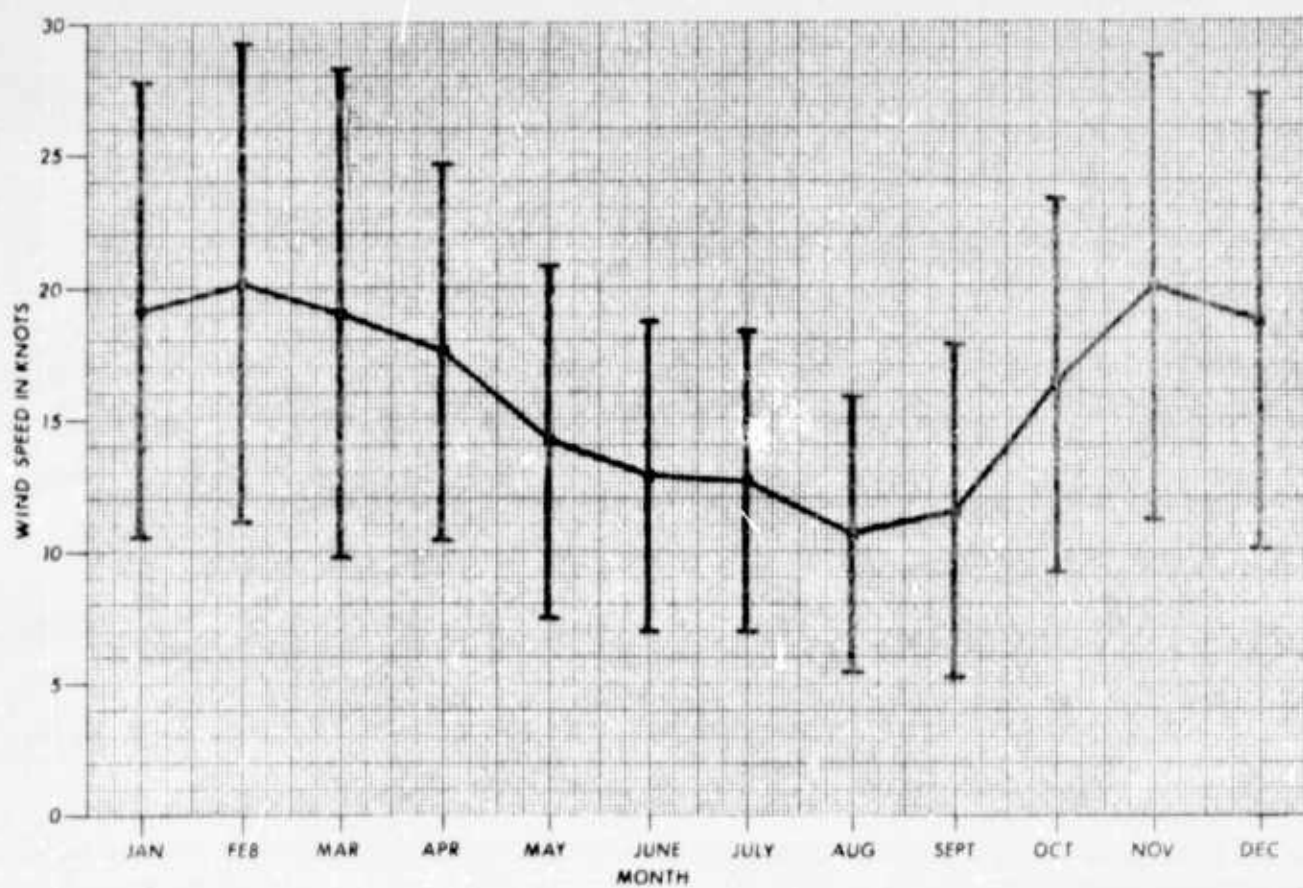


Fig. 5 - Monthly Mean Wind Speeds and Standard Deviations

DATA ANALYSIS

Wind-speed data read at one-hour intervals for a period of three years are examined herein, providing three sets of data for each calendar month.

To obtain the best estimate of the variation of the average monthly wind speed throughout the year, the three sets of data for each month were grouped in 1-knot intervals. From this set (approximately 2000 data points per calendar month) the median values with quartiles and the arithmetic means with standard deviations were computed. The results are shown graphically in Figs. 4 and 5 and for convenience are listed in Table 1.

Table 1

MONTHLY WIND SPEEDS AT ARGUS ISLAND					
Month	Wind Speed (knots)				
	Median	Upper Quartile	Lower Quartile	Mean	Standard Deviation
January	18.4	5.6	5.6	19.1	8.6
February	19.0	6.6	6.0	20.2	9.0
March	18.4	6.1	6.7	19.0	9.2
April	16.5	5.3	5.6	17.6	7.1
May	13.2	5.9	4.2	14.2	7.0
June	12.5	3.7	2.8	12.8	5.8
July	12.5	3.8	3.5	12.7	5.7
August	10.1	4.1	3.4	10.7	5.2
September	10.6	4.7	4.3	11.5	6.3
October	15.9	4.0	4.7	16.4	6.9
November	18.3	7.0	5.0	19.9	8.8
December	17.9	5.6	5.8	18.6	8.6

It should be noted that the data are somewhat biased, particularly in the sets for the fall months, by the omission of certain periods encompassing some of the highest speeds. (When possible, Argus Island is evacuated prior to the onset of a hurricane. The situation has since been modified to permit recording at Tudor Hill during periods of tower evacuation.)

As noted in Figs. 4 and 5, the curves of median and mean wind speeds are very nearly identical. The variation in the median value of wind speed over the entire year is 8.9 knots; the variation in the mean value is 9.5 knots. The values of standard deviation in Fig. 5 are rather high, apparently because of the effects of occasional violent storms in the area. It is therefore felt that the quartiles are a more satisfactory indication of the dispersion expected under usual wind conditions.

The variations in the quartiles range from 2.8 knots to 7.0 knots, while the standard deviations vary from 5.2 knots to 9.2 knots. The higher values occur in the winter months (with the higher wind speeds), and it is again assumed that the greater dispersions are caused by the high winds of individual storms.

February demonstrates the highest monthly median wind speed (19.0 knots) in the vicinity of Argus Island, while August provides the lowest value (10.1 knots). The months from May through September are represented by significantly lower wind speeds than are any of the remaining months.

To provide more detail regarding the wind-speed distribution within each month, the percent of occurrence of each 1-knot wind-speed interval of the total number of observations is plotted in Fig. 6. Again, each monthly curve includes the lumped data from three years of observations. Attention is once more called to the loss of some data during periods of high wind speeds.

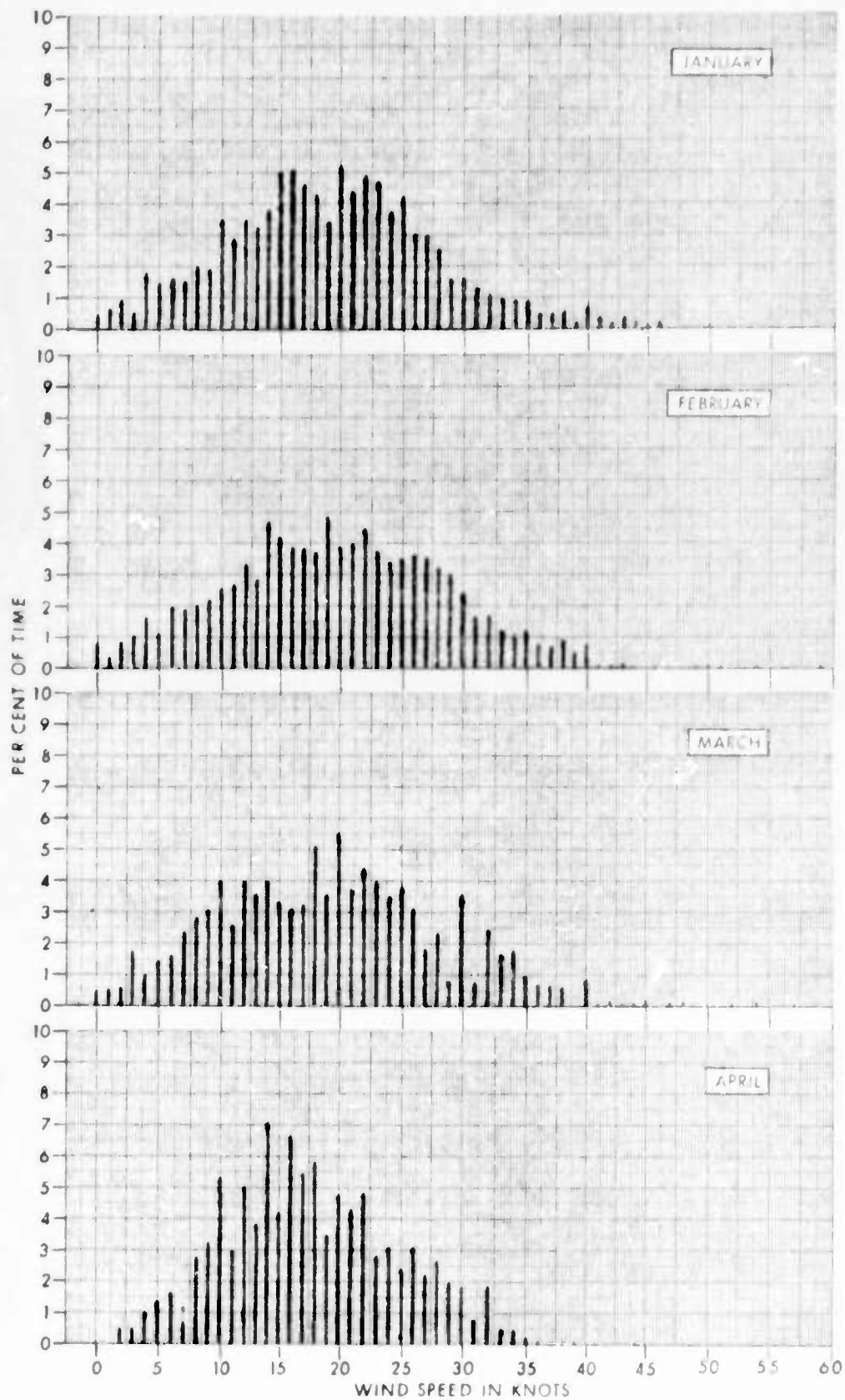


Fig. 6 - Monthly Wind-Speed Distributions

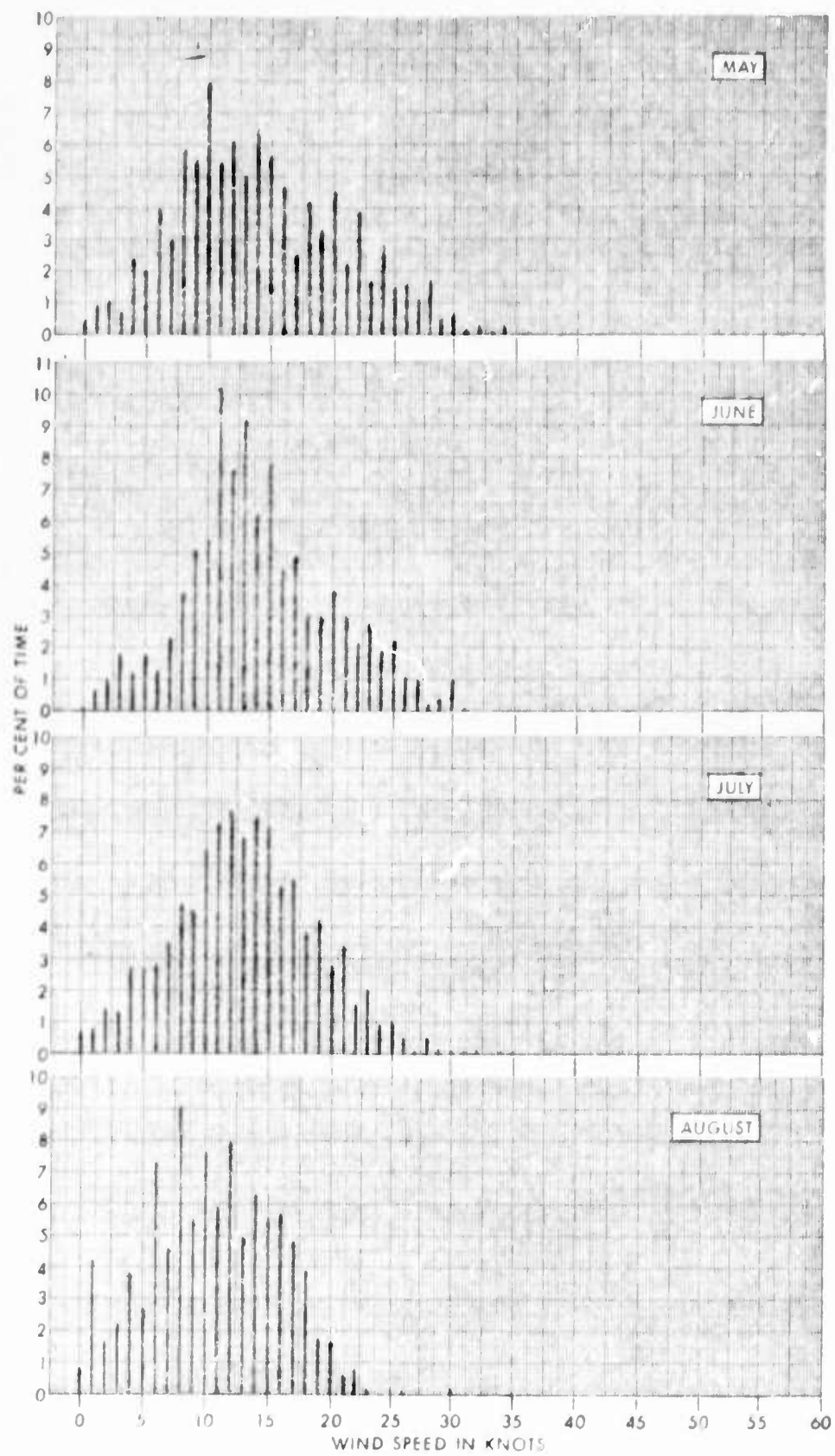


Fig. 6 (Cont'd) - Monthly Wind-Speed Distributions

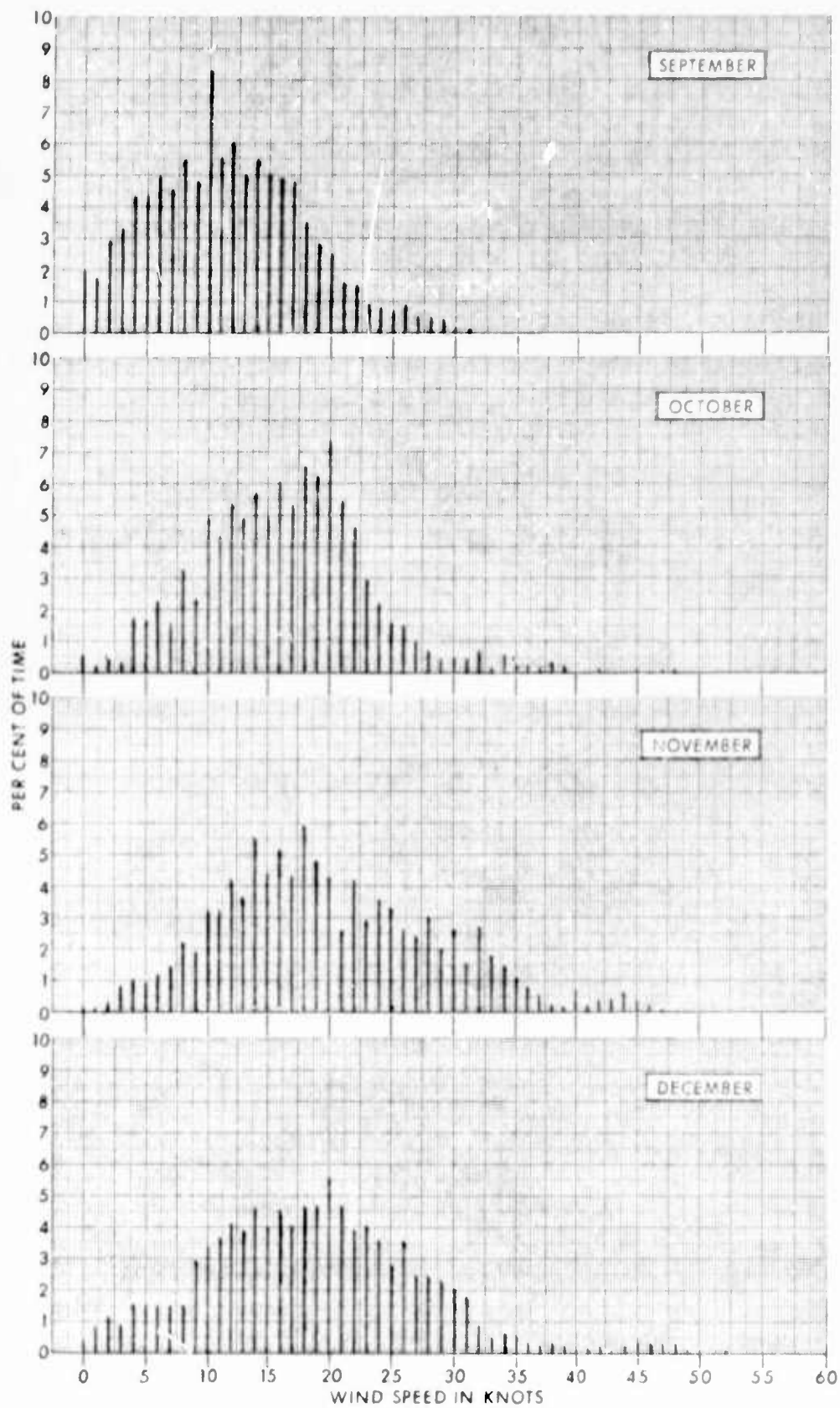


Fig. 6 (Cont'd) - Monthly Wind-Speed Distributions

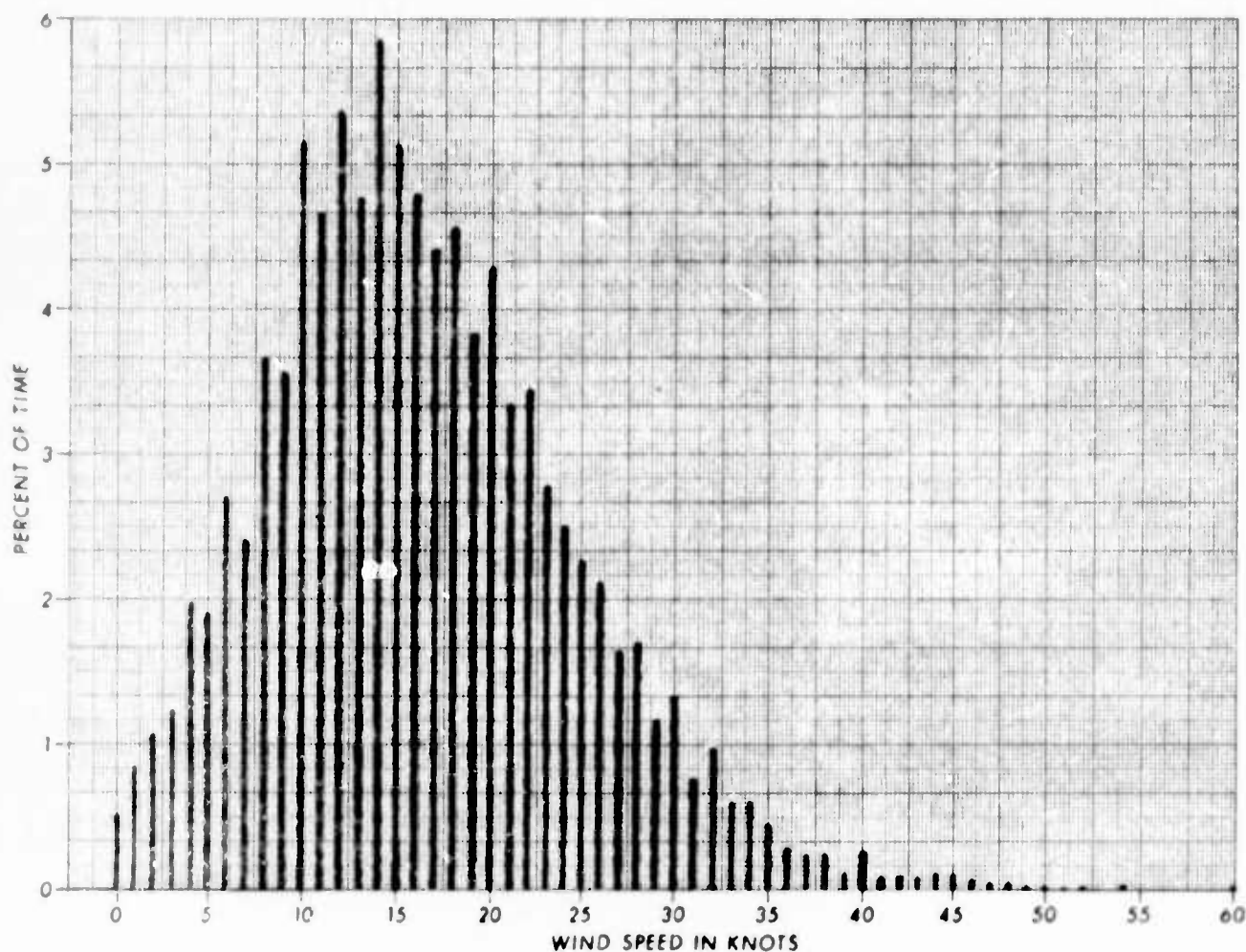


Fig. 7 - Yearly Wind-Speed Distribution (Three Years' Data)

Figure 7 presents the yearly distribution of wind speeds, this time lumping the 24,000 data points from three years of observations. All wind speeds observed are represented here, from May 1961 through April 1964. It is likely that the upper limit would have been extended had the wind speeds from all hurricanes been included.

Cumulative distribution of wind speeds is shown for each month in Fig. 8. The identities of the three sets of monthly data are retained in each case for comparison and for demonstration of the deviations from a normal distribution.

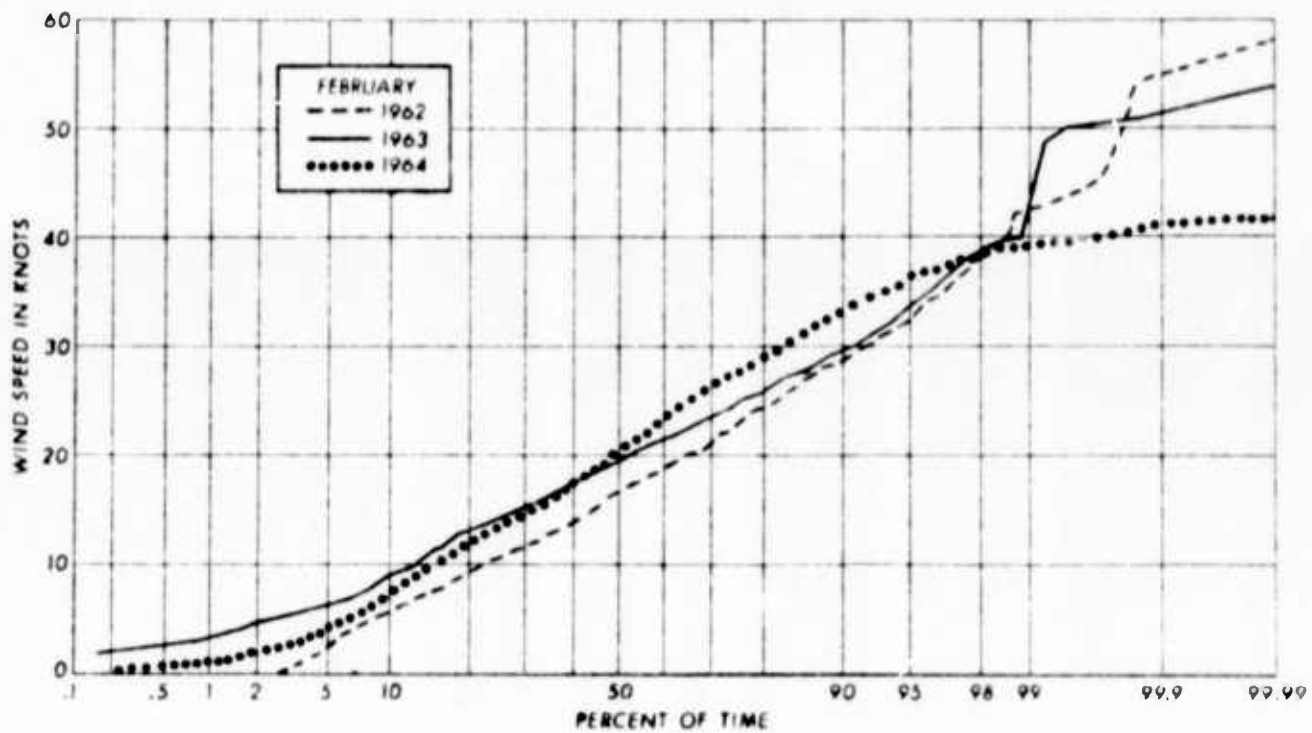
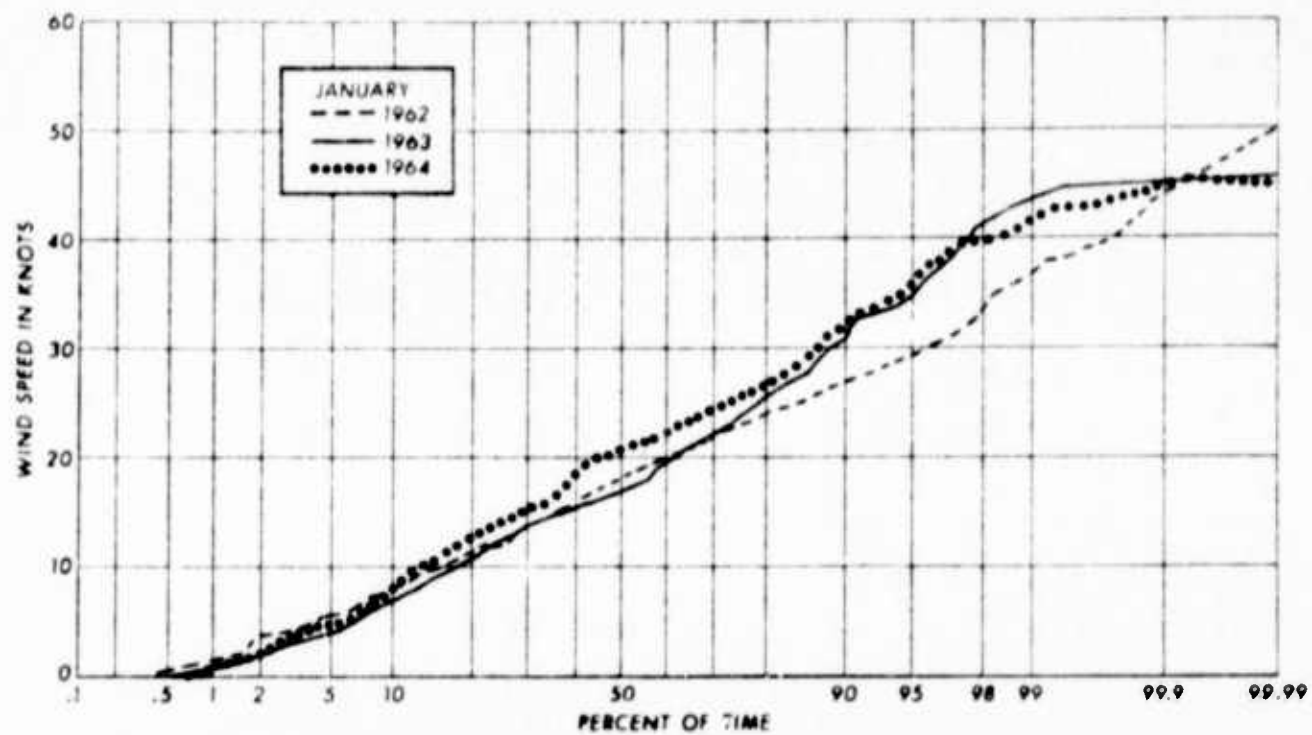


Fig. 8 - Cumulative Wind-Speed Distributions

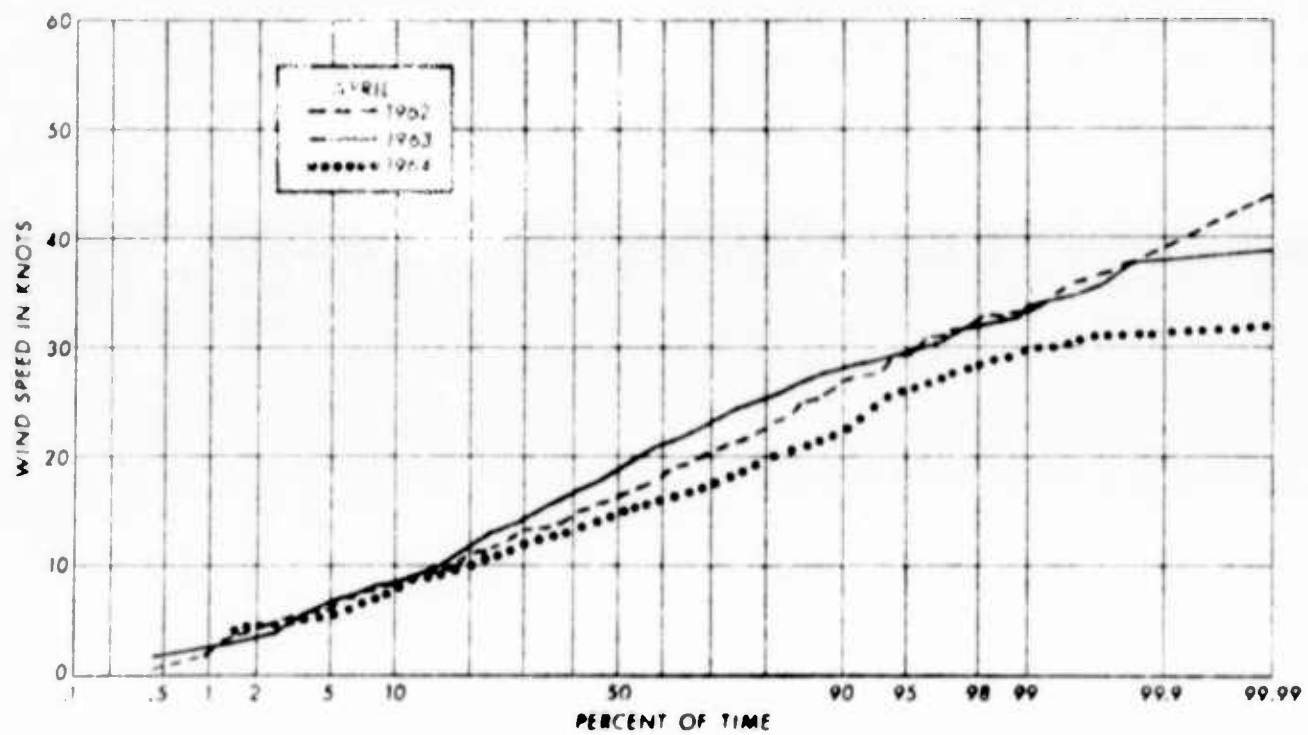
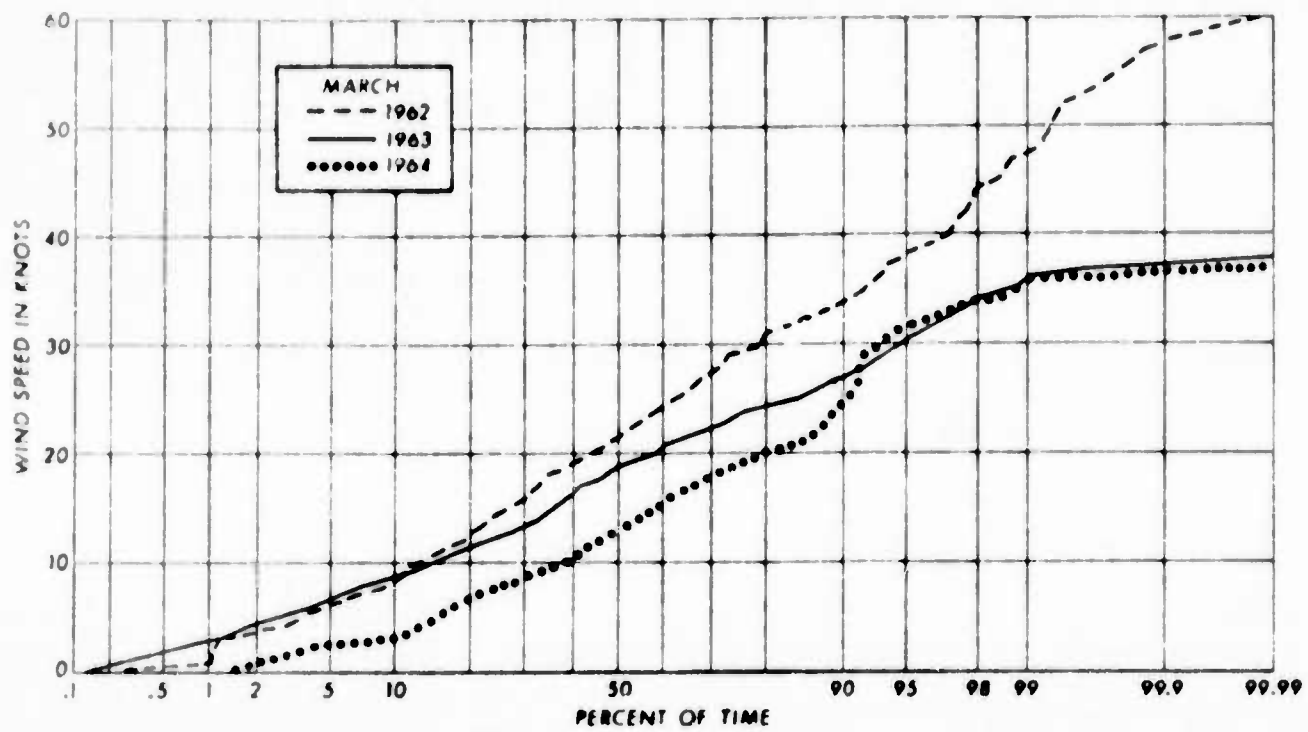


Fig. 8 (Cont'd) - Cumulative Wind-Speed Distributions

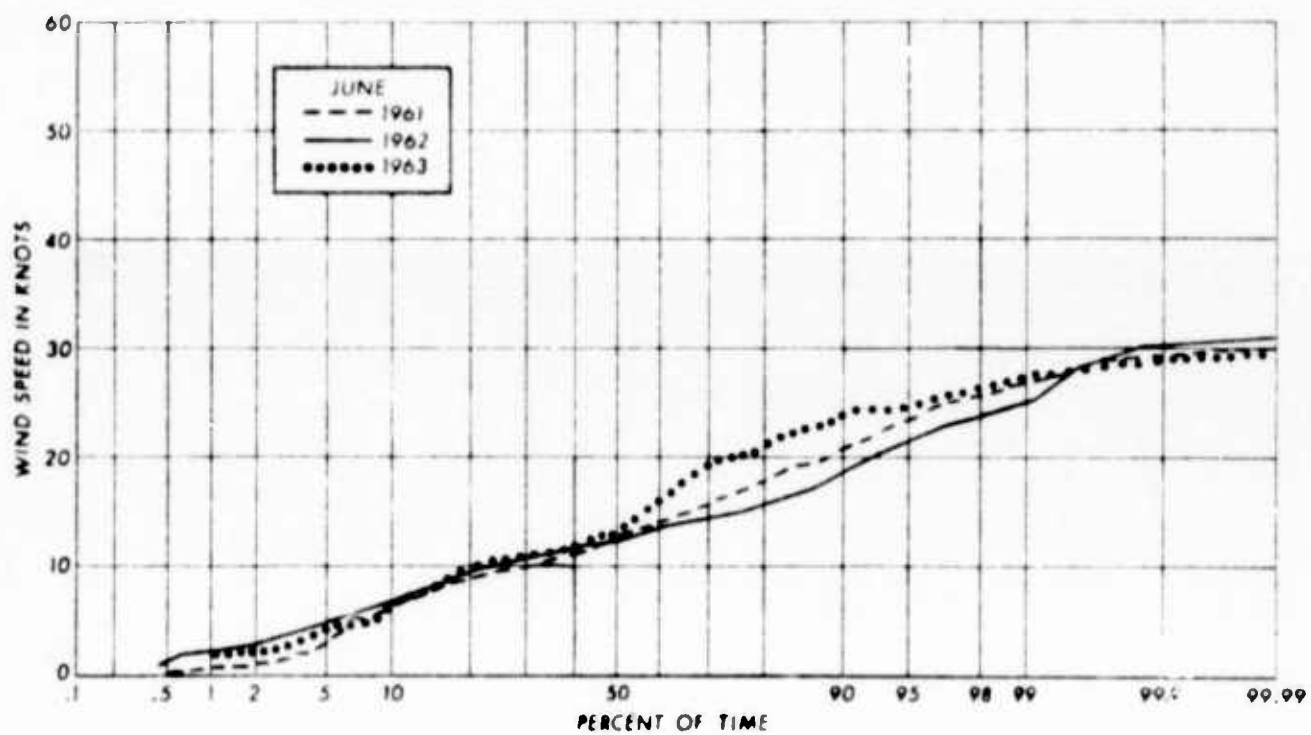
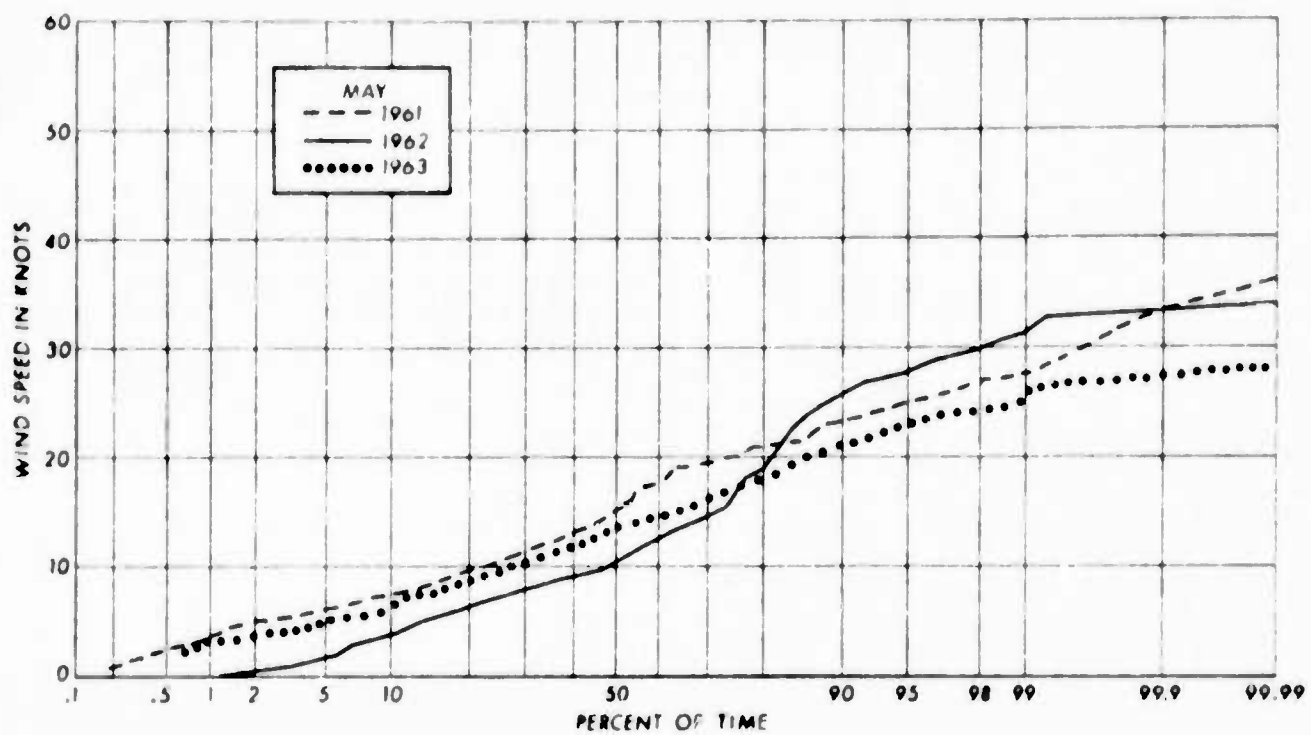


Fig. 8 (Cont'd) - Cumulative Wind-Speed Distributions

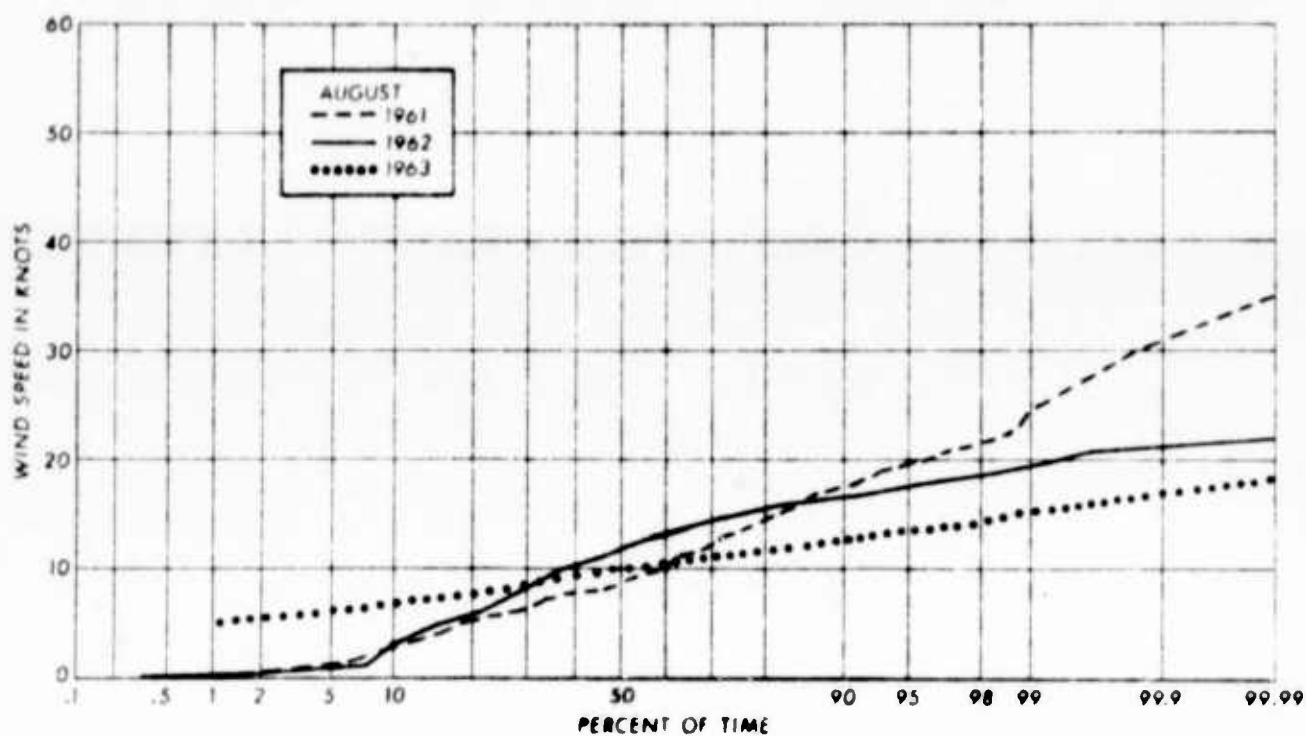
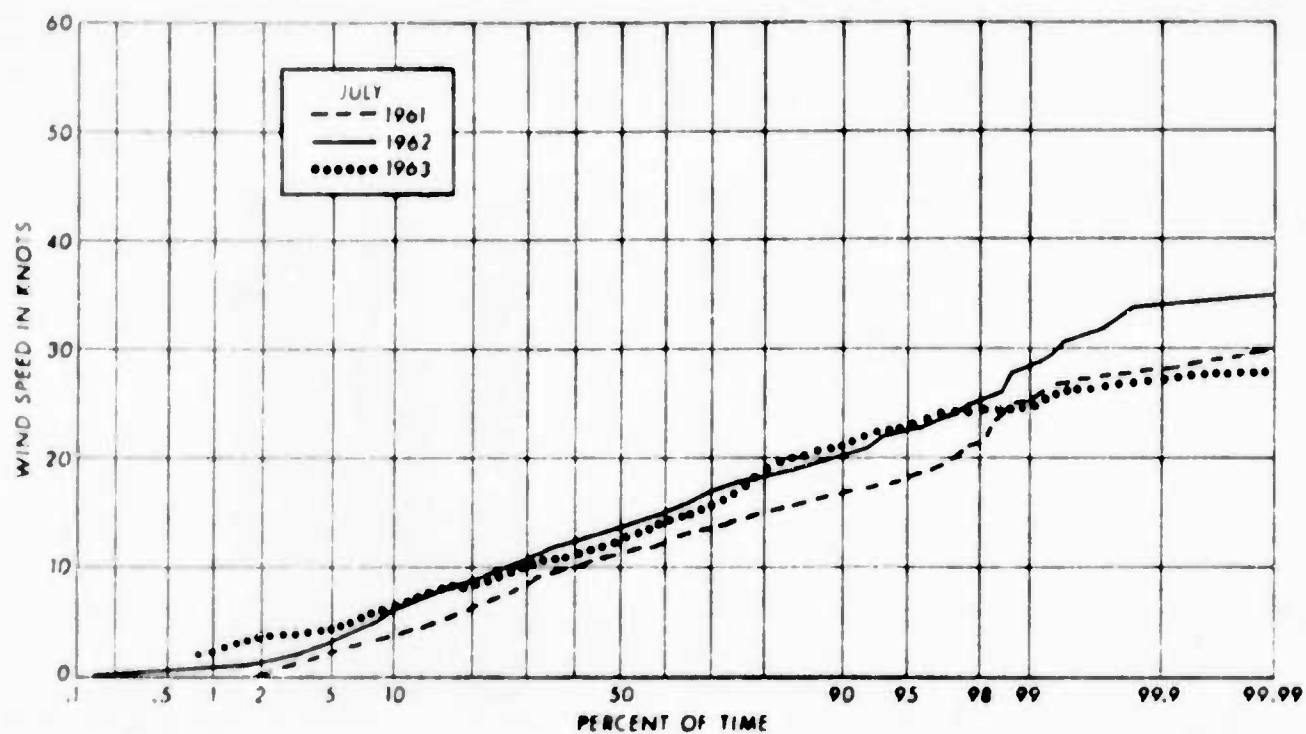


Fig. 8 (Cont'd) - Cumulative Wind-Speed Distributions

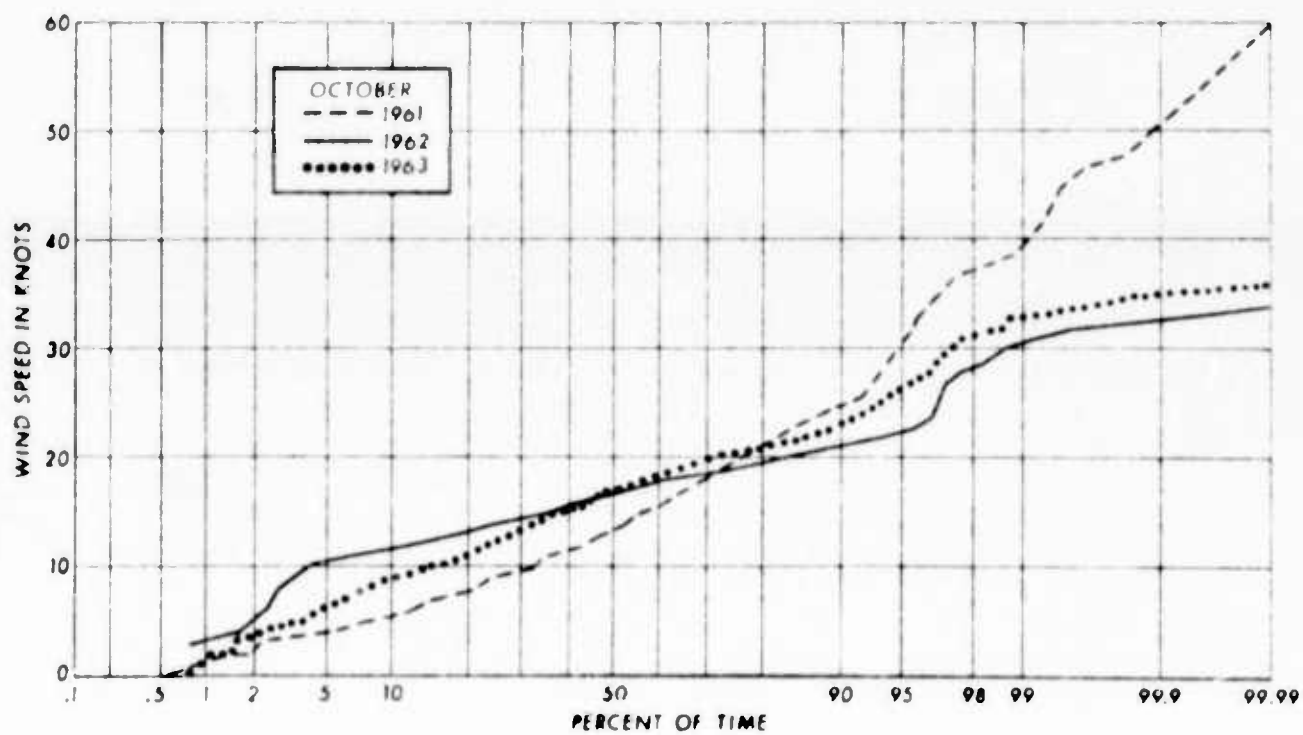
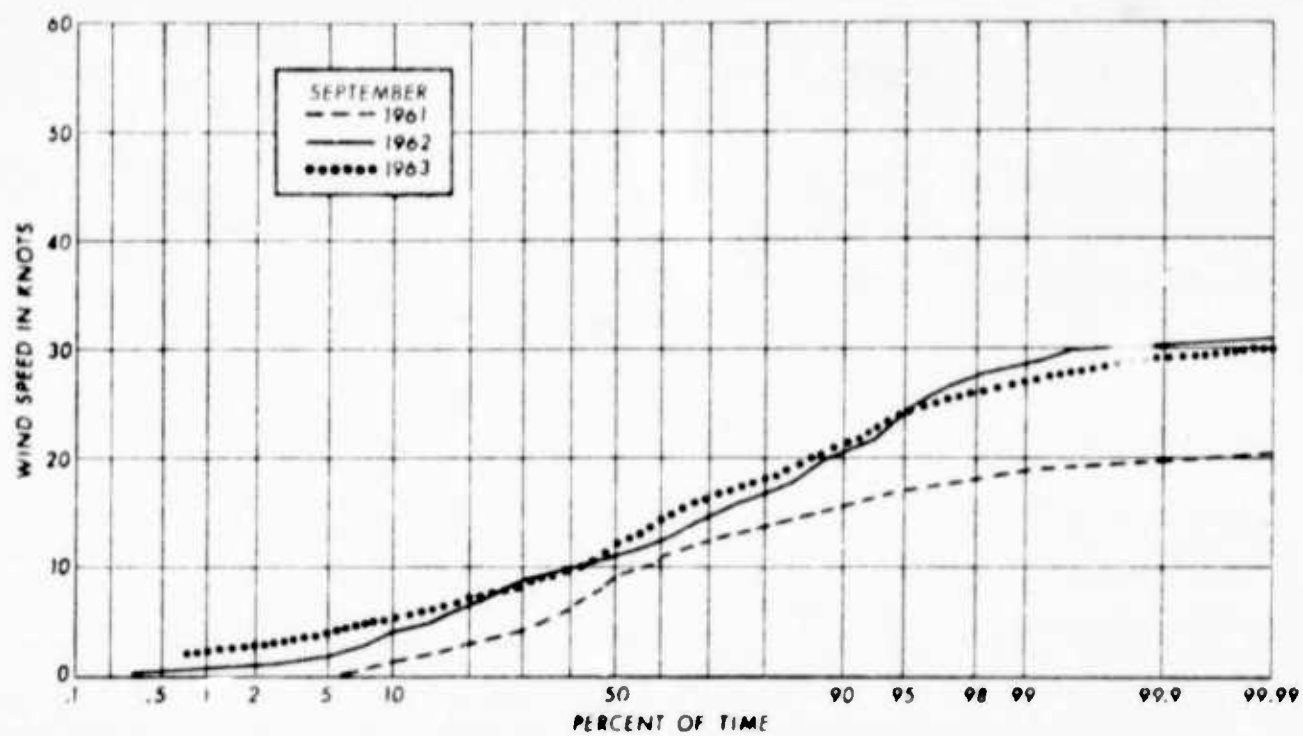


Fig. 8 (Cont'd) - Cumulative Wind-Speed Distributions

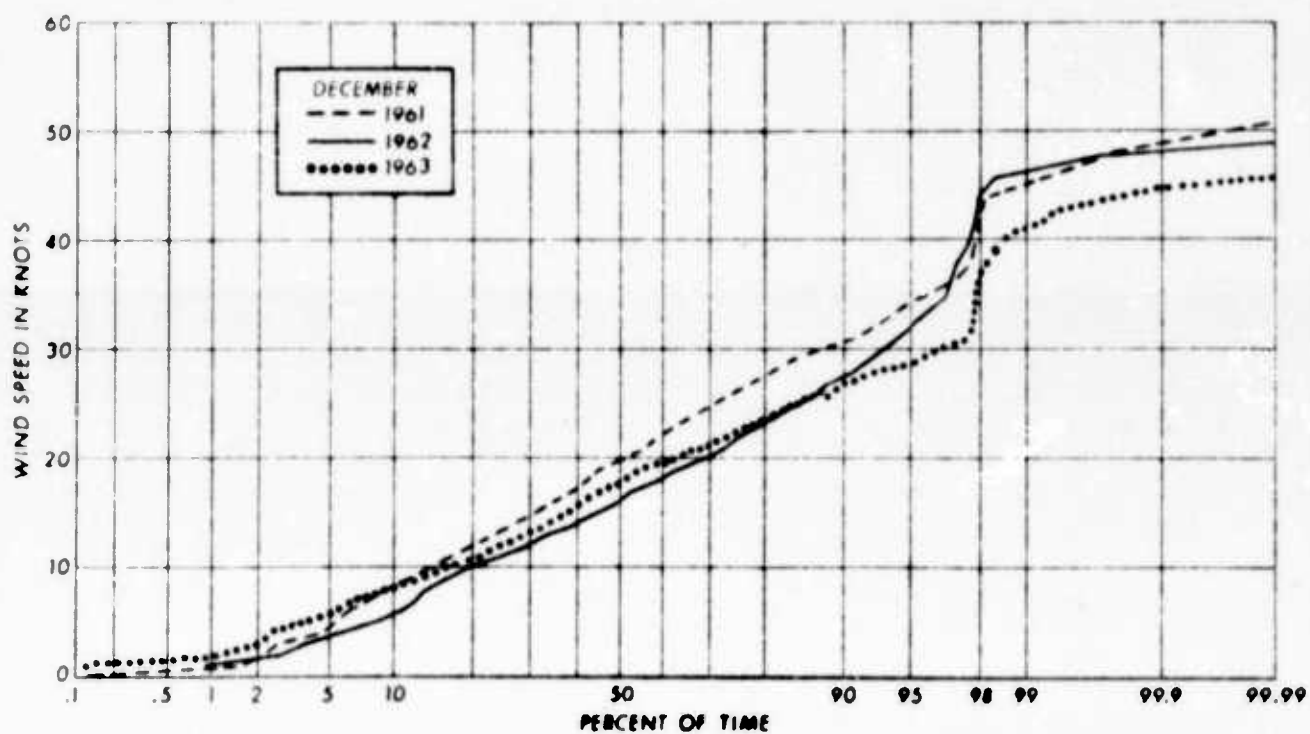
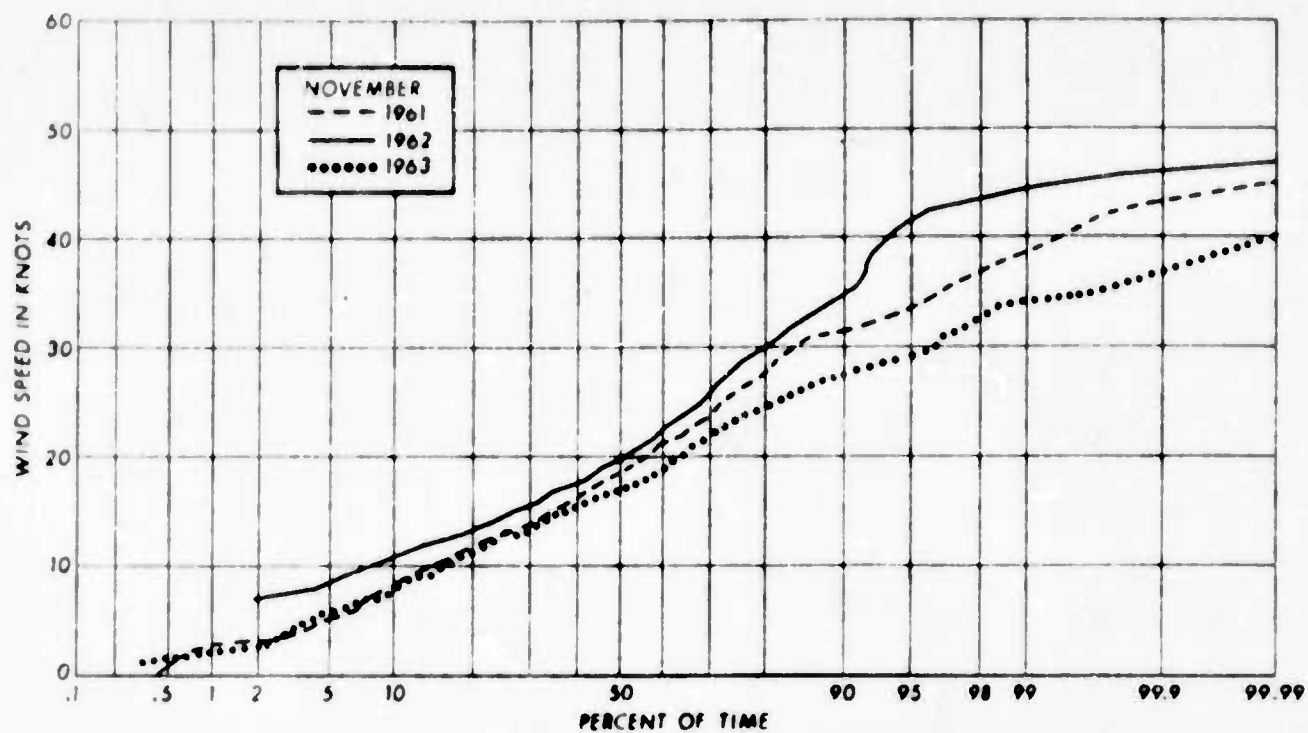


Fig. 8 (Cont'd) - Cumulative Wind-Speed Distributions

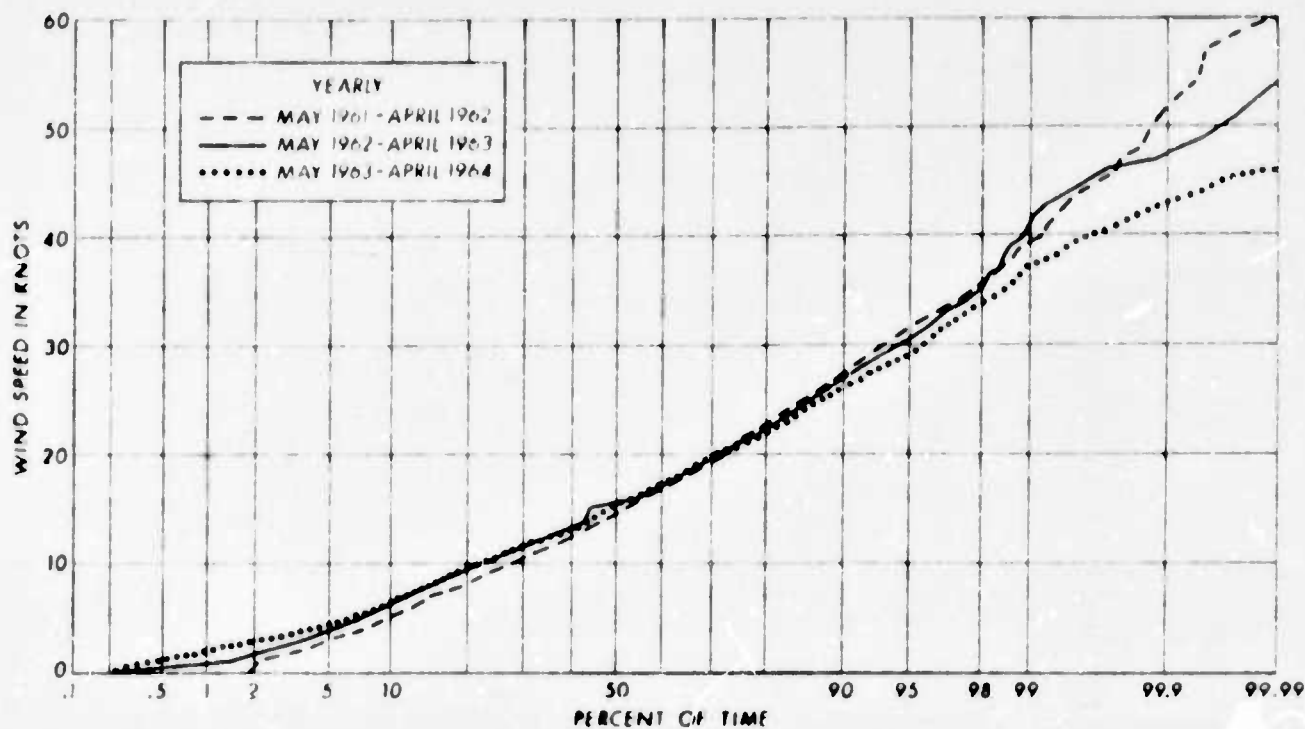


Fig. 9 - Yearly Cumulative Wind-Speed Distributions

Figure 9 shows the cumulative distributions for each of the three years considered.

A condensed history of the wind speeds recorded at Argus Island from May 1961 to September 1964 is given in Fig. 10. Values of daily mean wind speed and daily maximum wind speed have been plotted, and the area between these two curves has been shaded — hence the width of the trace. Periods for which data are missing are noted in the figure.

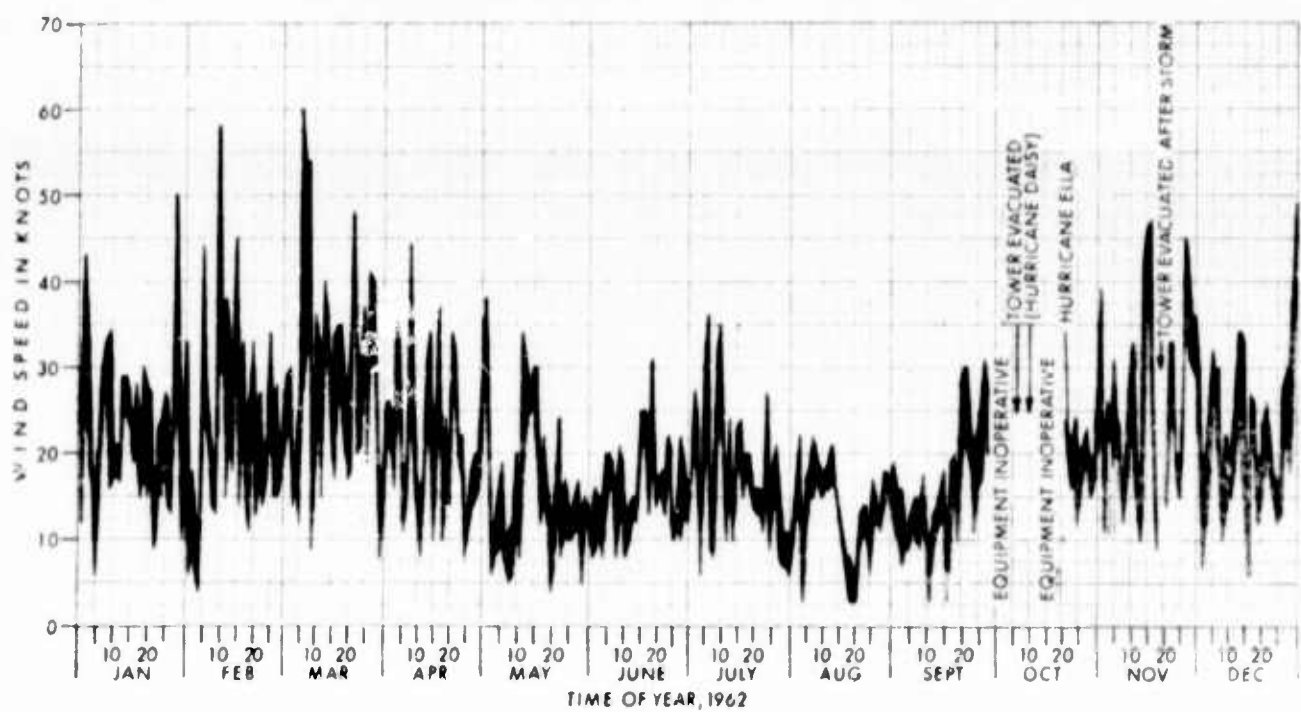
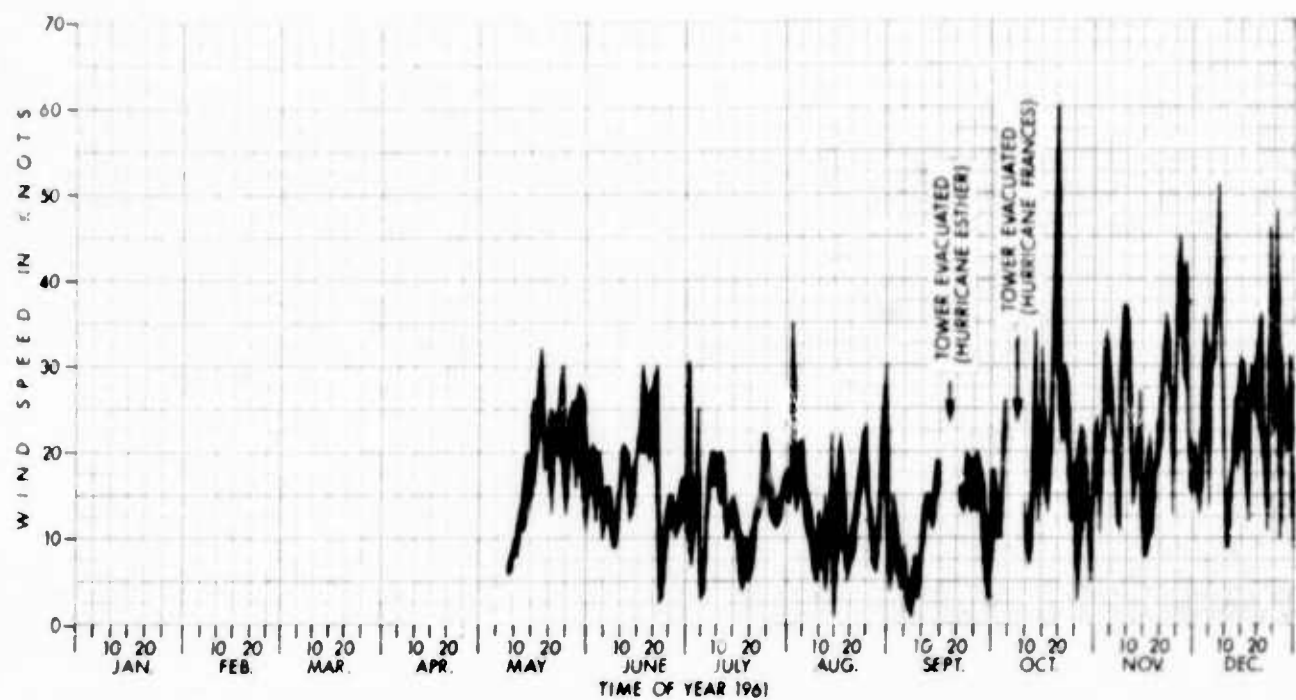


Fig. 10 - Daily Maxima and Mean Wind Speeds at Argus Island

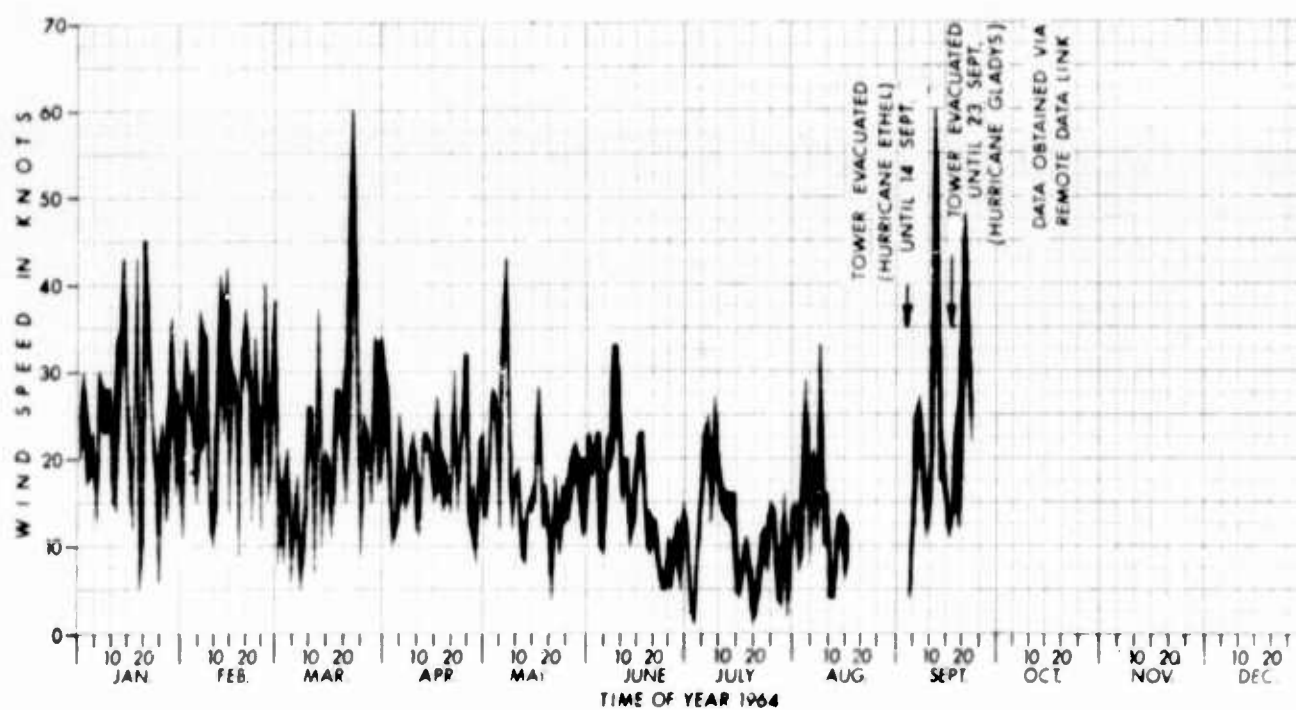
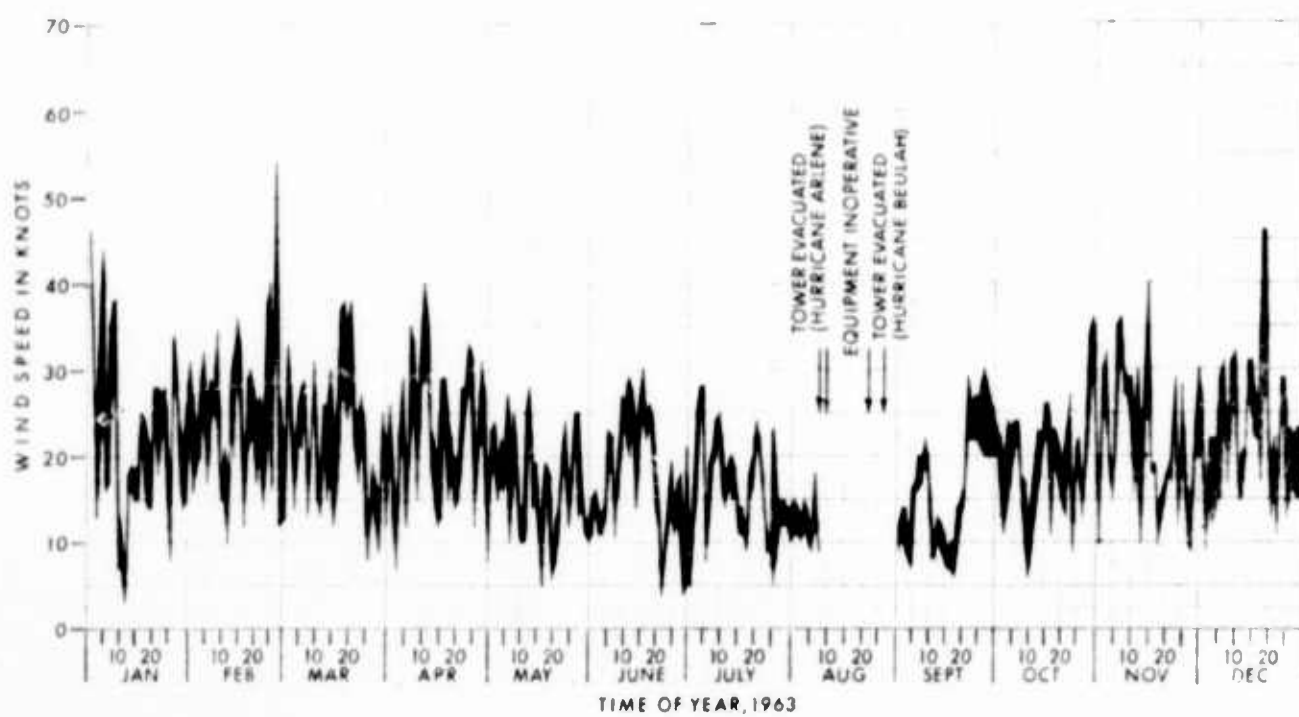


Fig. 10 (Cont'd) - Daily Maxima and Mean Wind Speeds at Argus Island

DIURNAL VARIATION OF WIND SPEED

The data were further examined to investigate the existence of diurnal variations in wind speed. An "average day" for each of the twelve months was plotted in the form of wind speed versus time of day (at two-hour intervals). No discernible daily pattern appeared. If any wind-regulating effects originate with the land mass of Bermuda, they apparently do not extend as far seaward as Argus Island.

WIND DIRECTION

Wind direction data recorded at Argus Island have also been tabulated and plotted and are reproduced here. Figure 11 shows that the winds were generally westerly (ranging from south to

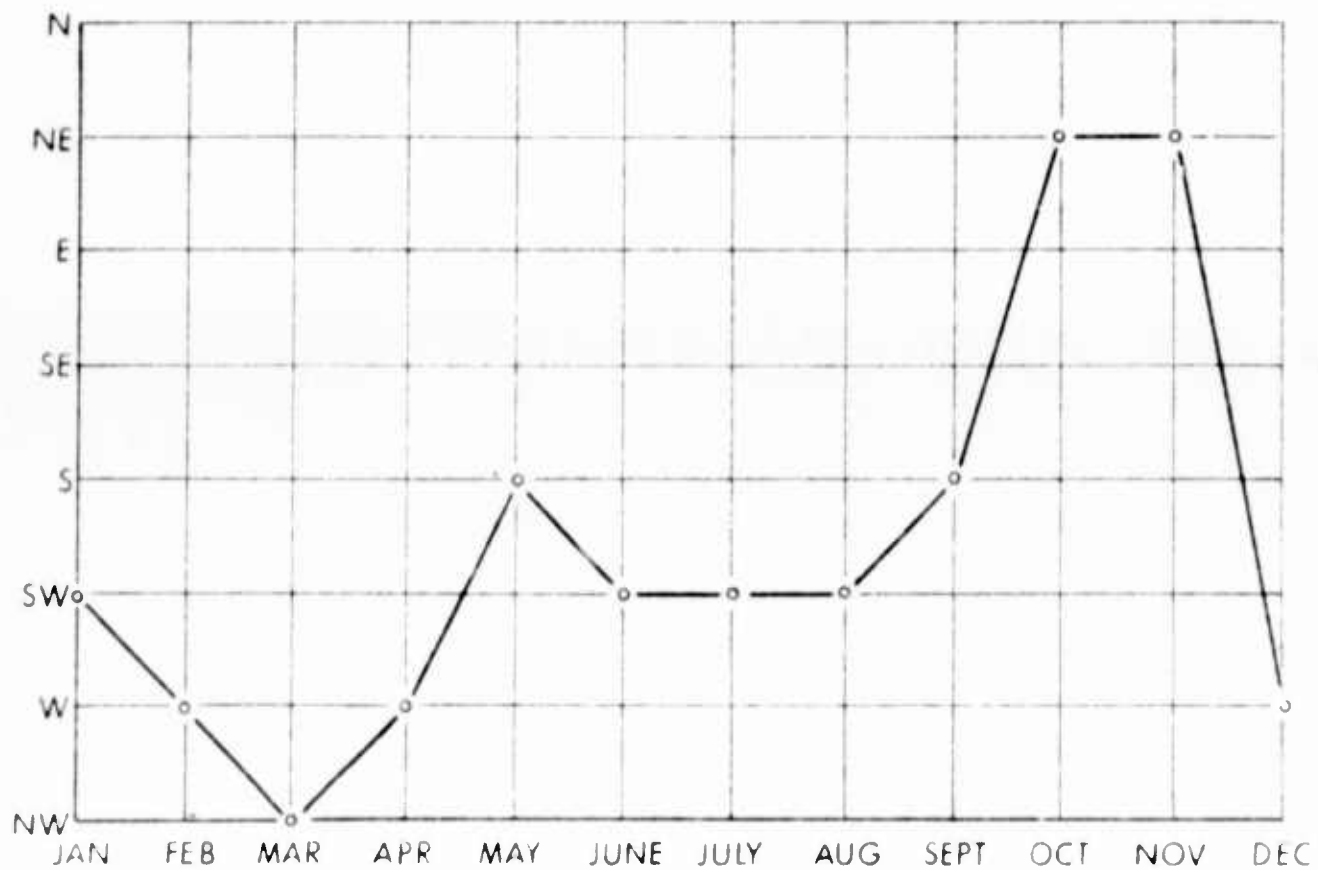


Fig. 11 - Predominant Monthly Wind Directions at Argus Island

northwest) except during the months of October and November, when winds from the northeast predominated.

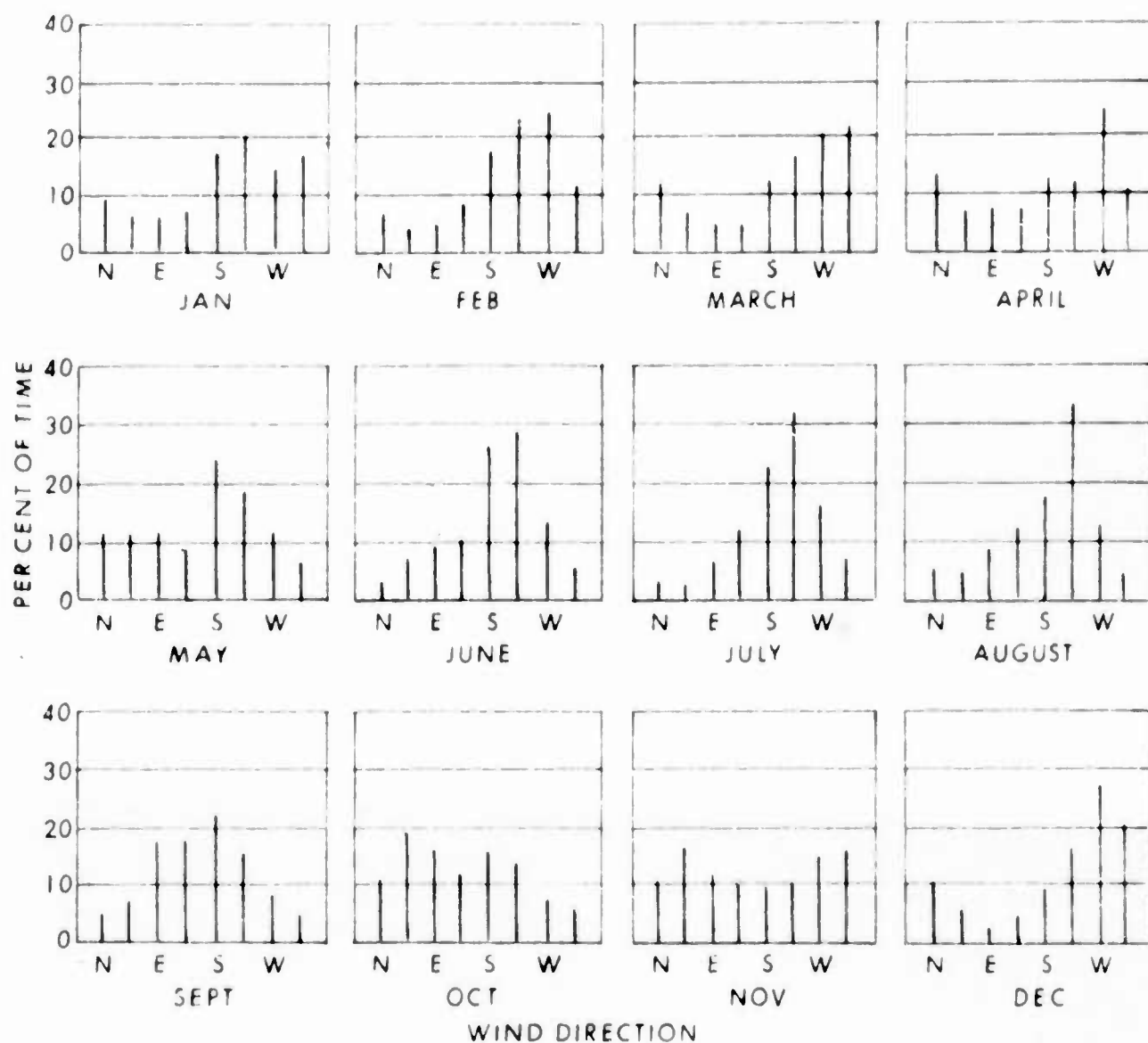


Fig. 12 - Monthly Wind-Direction Distributions at Argus Island

The distribution of wind direction for each month of the year is shown in Fig. 12. The predominant southerly direction during the months of May through August is evident, corresponding to the period of low wind speeds shown in Fig. 4.

Finally, Fig. 13 is a polar plot summarizing the monthly means of wind speed and wind direction.

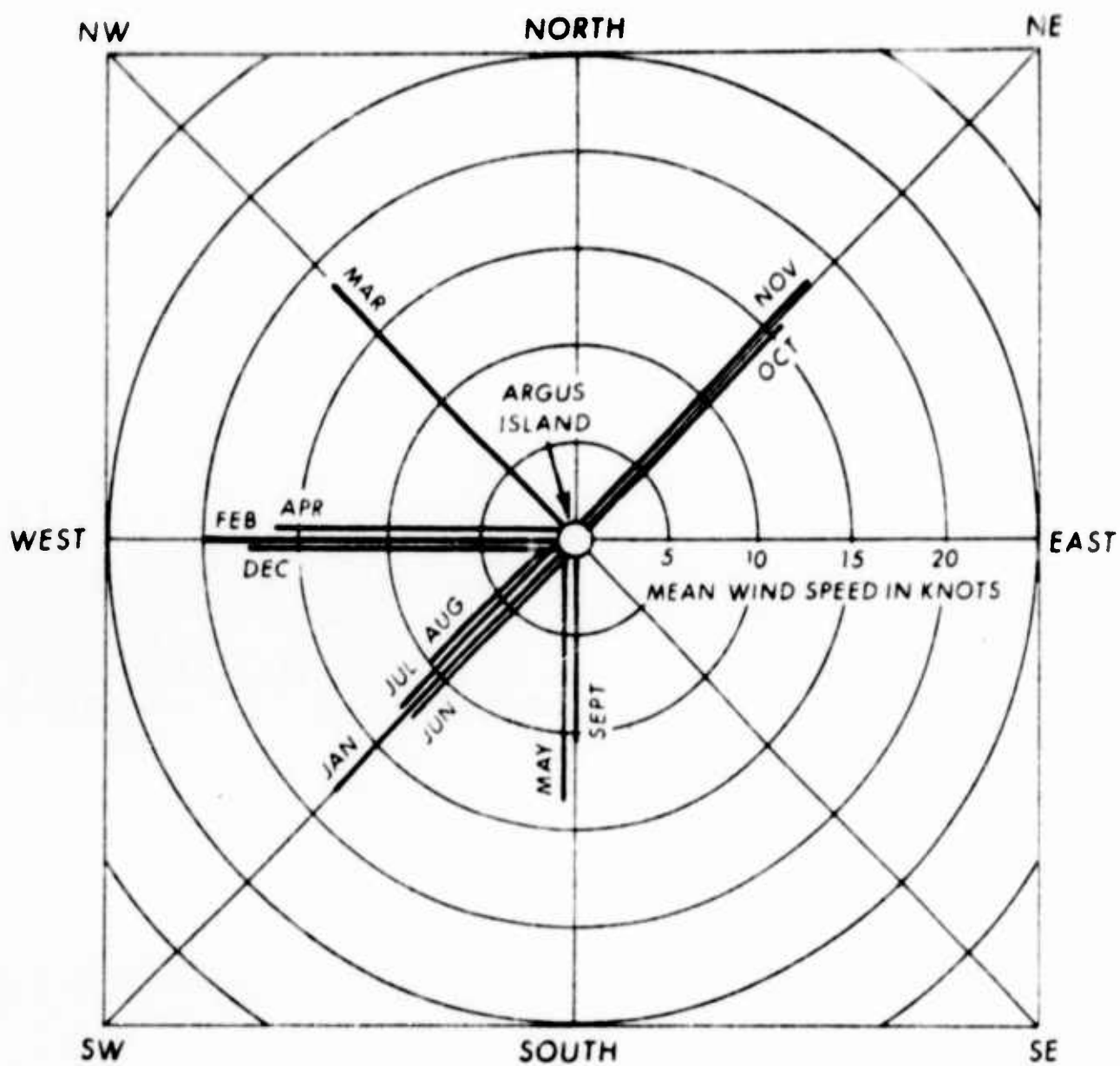


Fig. 13 - Summary Plot of Monthly Means of Wind Speed and Direction